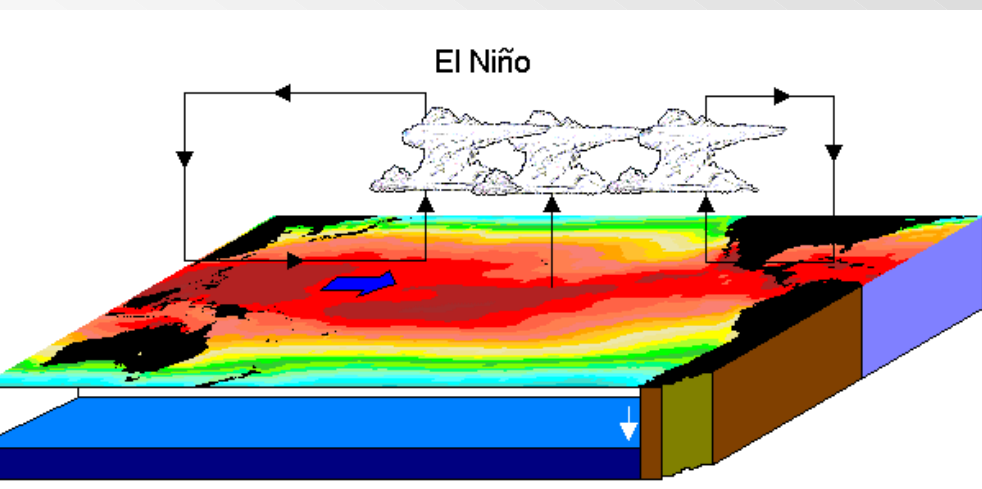
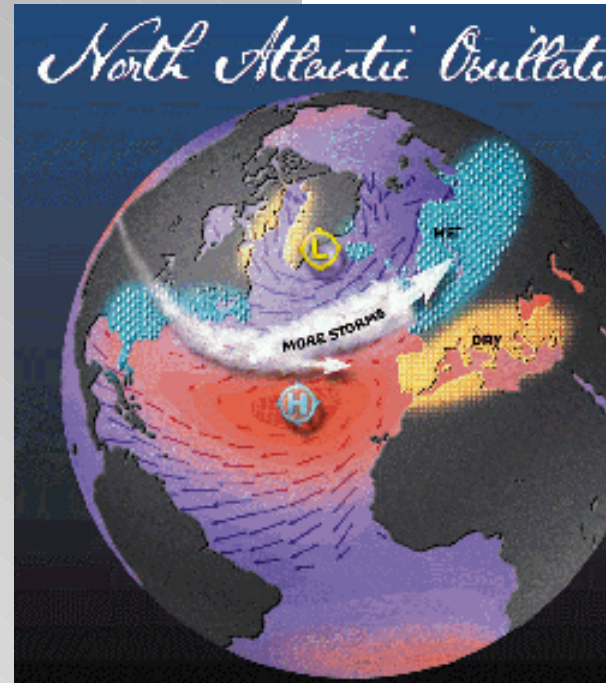


Oceans and Ice

Science, Observations,
Technology

Chet Koblinsky
NASA/GSFC



Presentation at
NASA Earth Science Enterprise
Technology Planning Workshop
Arlington, Virginia
January 23, 2001

Oceans and Ice

Some NASA ESE Science Questions

- How is the global ocean circulation varying on interannual, decadal, and longer time scales?
- How can climate variation induce changes in the global ocean circulation?
- What changes are occurring in the mass of the Earth's ice cover?
- How global sea level affected by climate change?

Ocean Observations: A Vision

New era for oceanography

Global, integrated, sustained

Multi-purpose →

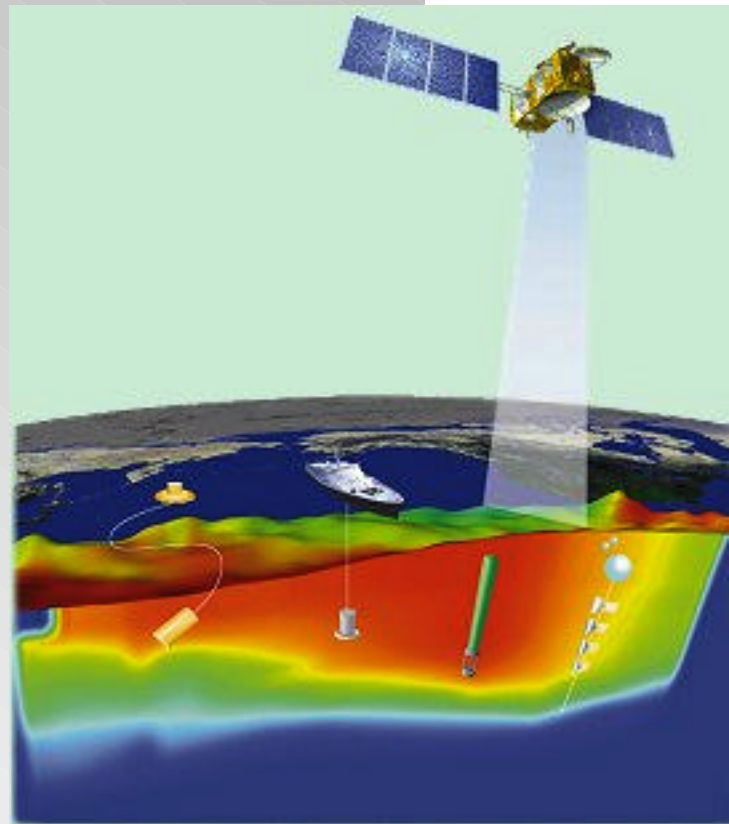
- efficiency, broader investment base

A system

- Scientific, priorities

A schedule of action

Research and operational: working together



strategy for a global ocean observing system based on the International Conference on Ocean Observations for Climate, 1999 is available at :

<http://www.bom.gov.au/OceanObs99/Papers/Statement.pdf>



Oceans and Ice

Summary of Satellite Observables

- Existing:
 - Sea Surface Temperature, Winds, Topography
 - Sea Ice Concentration, Extent, Motion
 - Ice Sheet Topography, Velocity
- Development:
 - Sea Surface Salinity, Mixed Layer Depth
 - Sea Ice Thickness
 - Ice Sheet Thickness, Internal Temperature and Layers

Conclusions

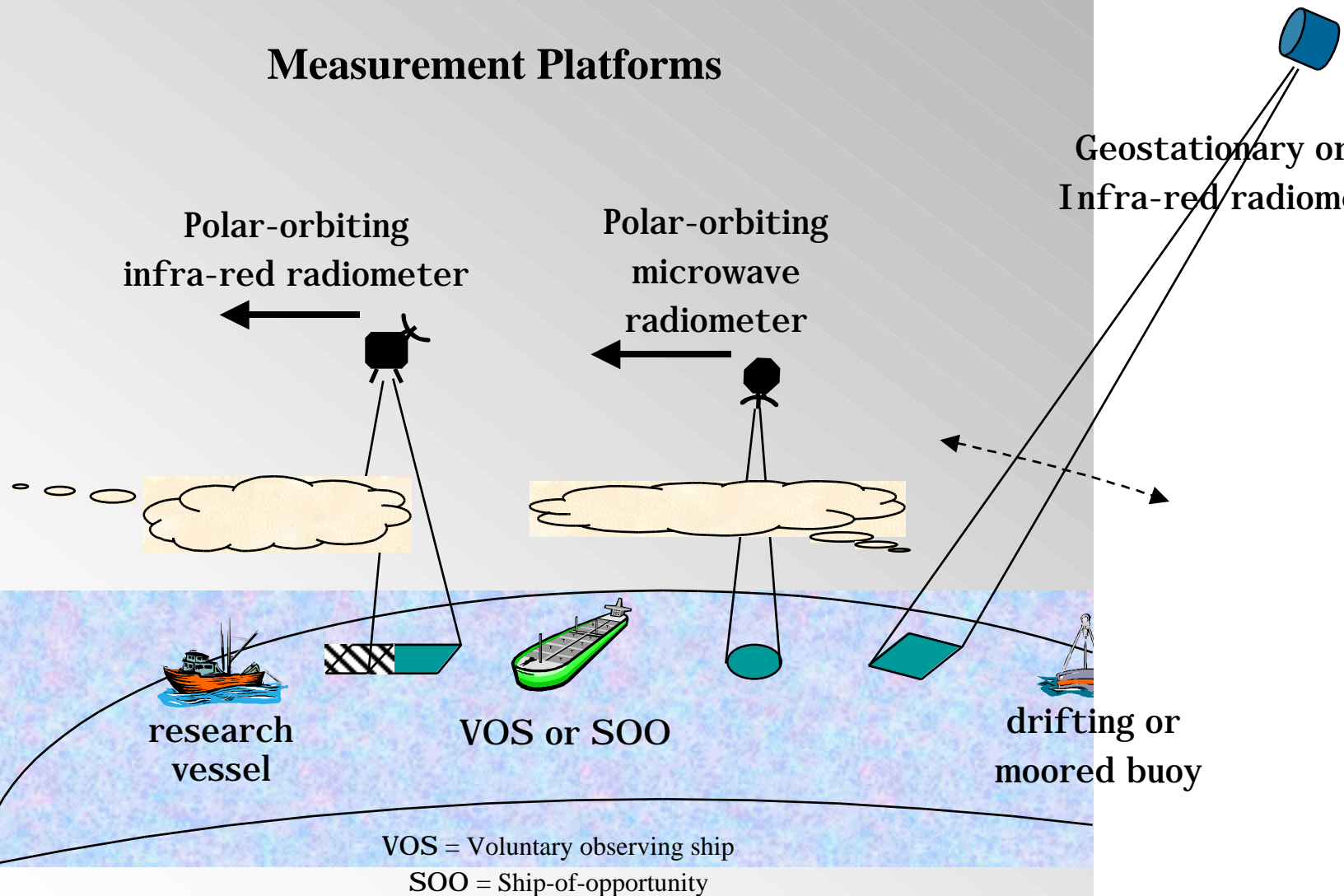
Technologies Needed For Oceans and Ice 2005-2015

- | | |
|------------------------|--------------------------------|
| • Large Antenna | Temperature, Salinity, Sea Ice |
| • Laser Technology | Mixed Layer Depth, Topography |
| • Precision Navigation | Topography |
| • Formation Flying | Salinity, Winds, Topography |
| • On Board Processing | Sensor Webs |
| • Communication | Sensor Webs |
| • IR Sensors | Temperature |
| • Miscellaneous | 100Mhz Radar, interferometry |

Sea Surface Temperature

“An important indicator of air-sea coupling and the most critical field for global coupled models”

Measurement Platforms



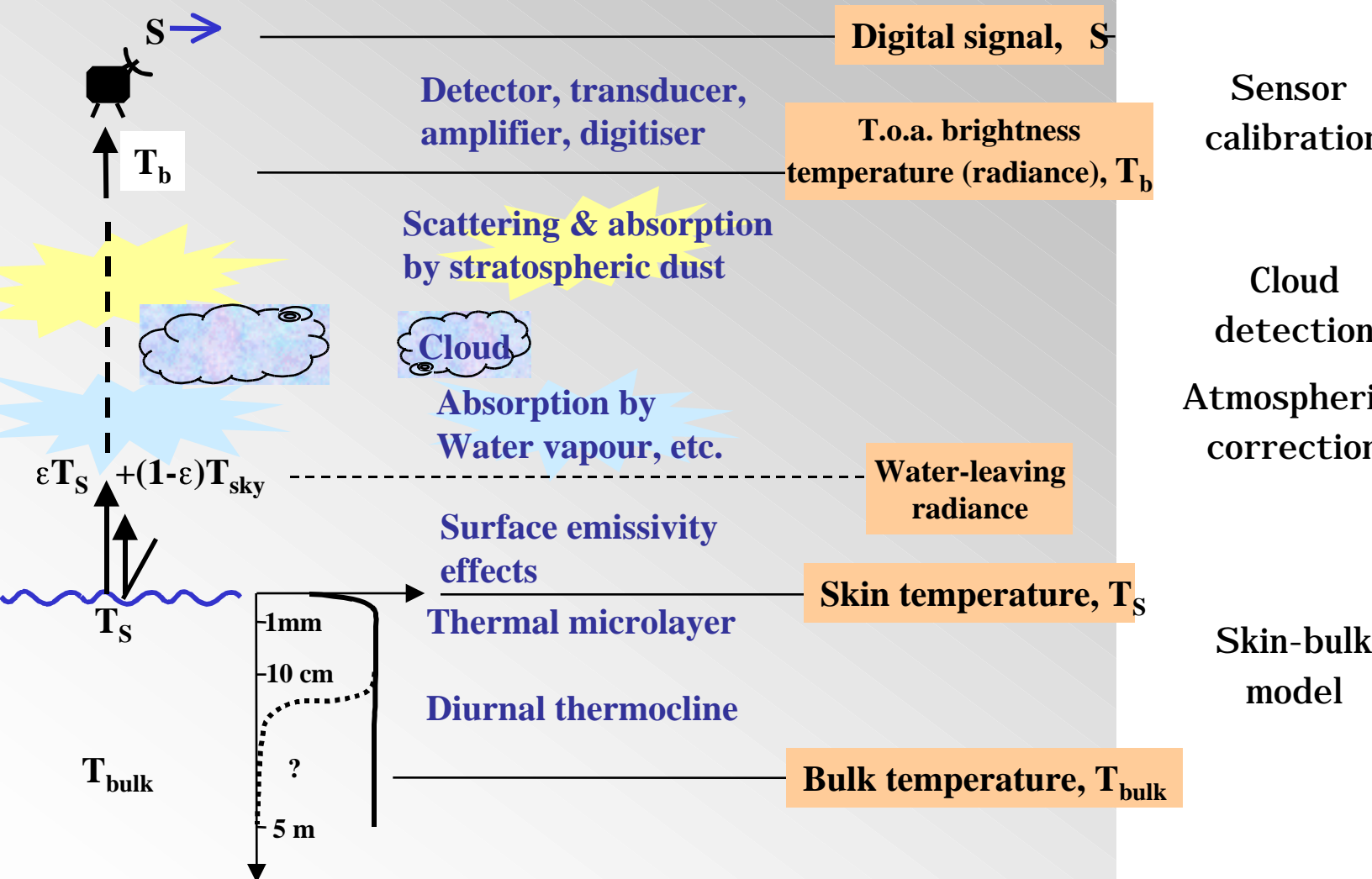
Processes affecting SST Measurement

Flow of information

Processes

Temperature Measure

Procedures

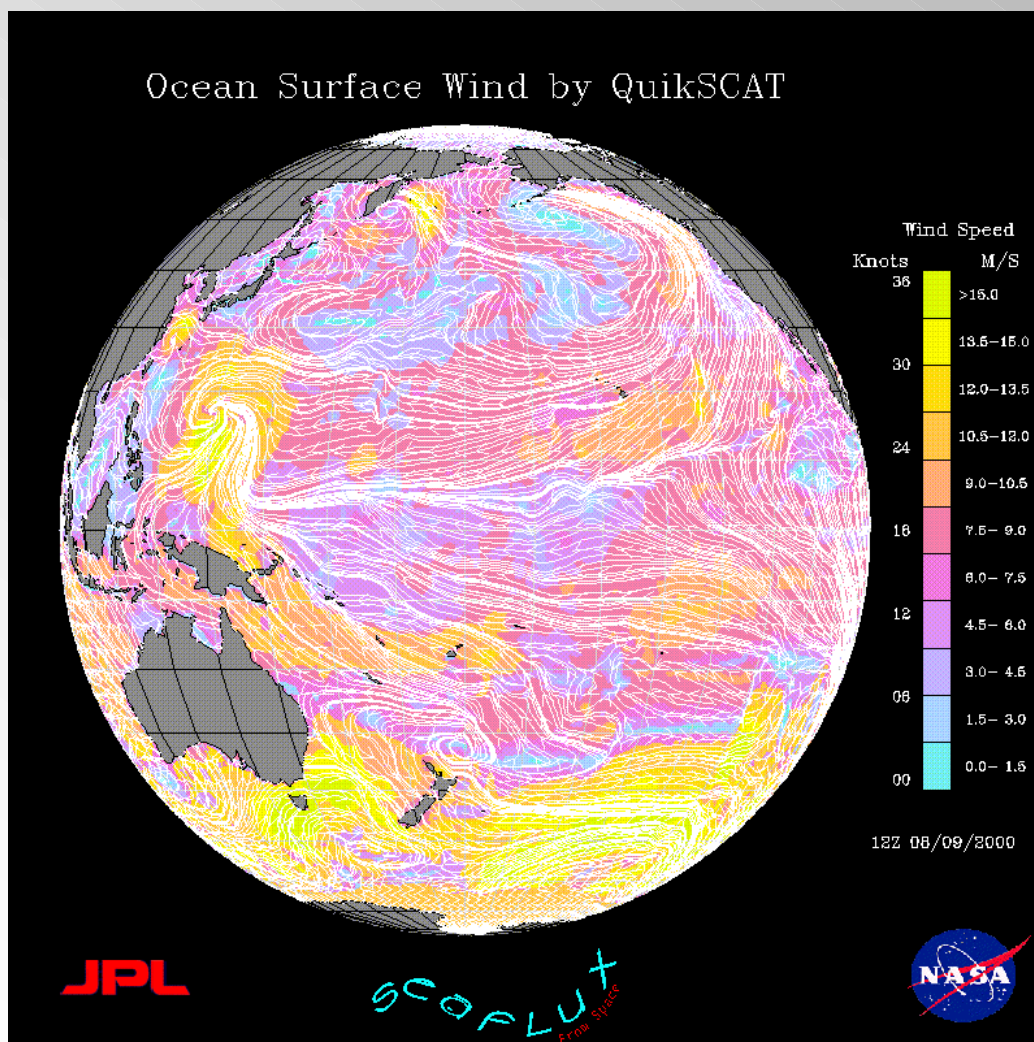


Sea Surface Temperature

- 00-05 Plan: Continue merged products with IR, passive microwave, geostationary, and in situ observations
- 05-15 Challenges:
 - Accuracy (0.1K) - AATSR/skin-bulk differences;
 - Coverage (all weather at 10km) - passive microwave; and
 - Temporal resolution (resolve the diurnal cycle) - Geostationary.
- Technology: Improved IR detectors, large steerable antenna for microwave, remove atmospheric effects through multi-frequency systems.
- Large Deployable, Lightweight Antenna; IR telescopes

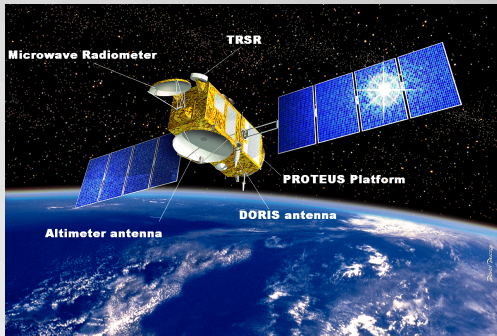
Sea Surface Winds

The primary ocean forcing function



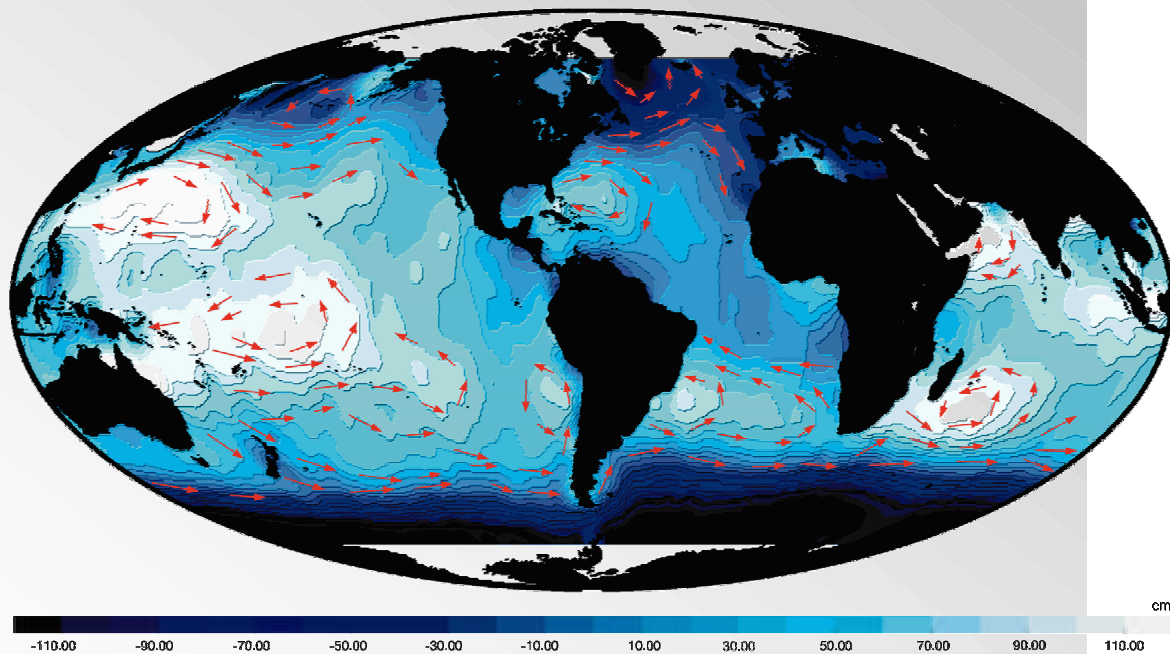
Sea Surface Winds

- 00-05 Plan: 2 wind vector scatterometer satellites (NASA, ESA), test of passive microwave approach (Windsat-NRL)
- 05-15 Challenges:
 - Develop passive microwave approach (CMIS),
 - Improve coverage (3 day \rightarrow 3 hour), resolution (25km \rightarrow 5 km);
 - Remove directional ambiguity.
- Technology: Low mass multiple beam antenna-potentially using steerable antenna- deployable antenna configuration. Integration of interferometric velocity measurements into directional ambiguity resolution method. Polarimetric scatterometer. Formation flying.



Surface Topography

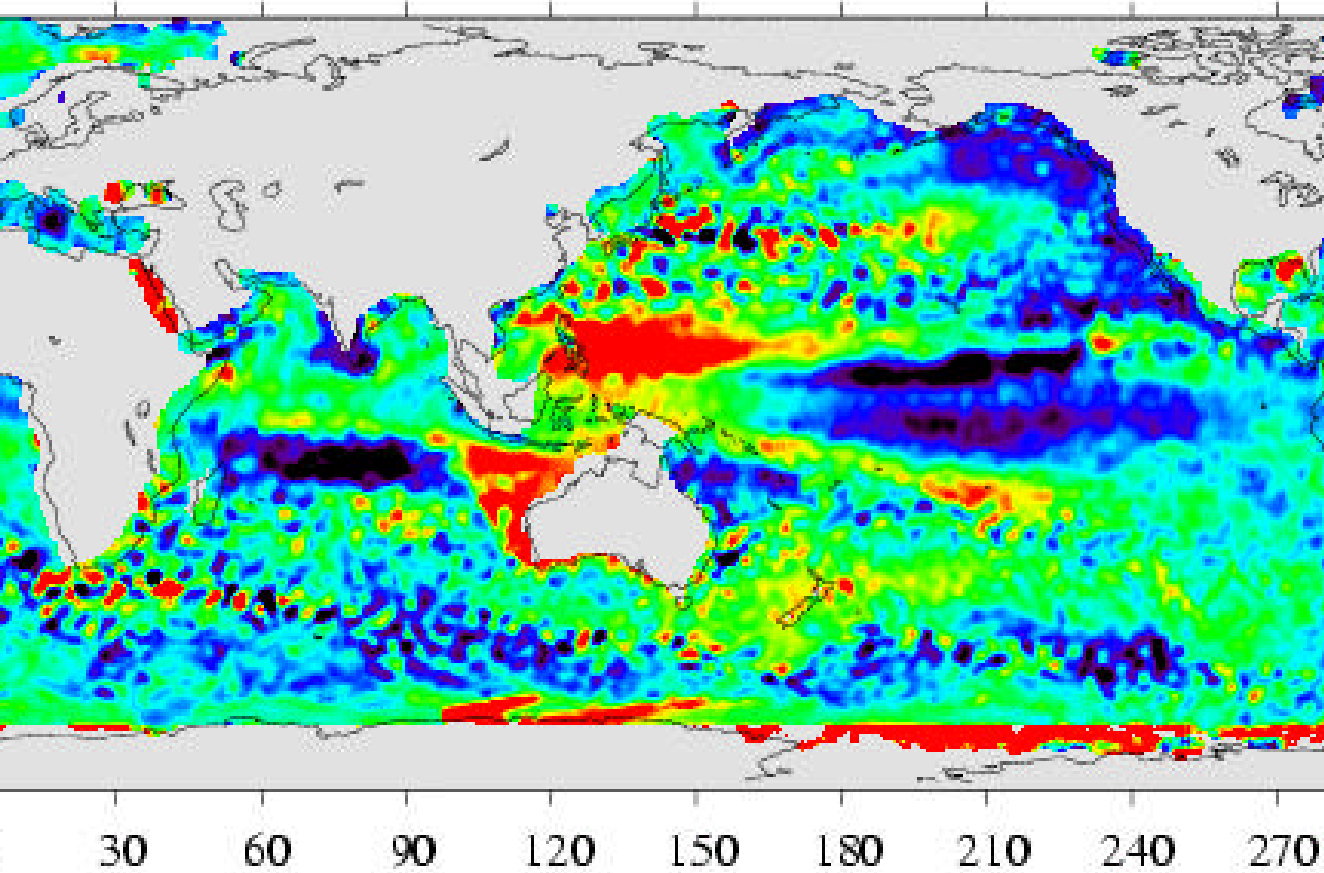
**Monitoring ocean circulation and dynamics
and global sea level changes.**



Sea Surface Topography Anomaly, June, 1999

First View from Combined TOPEX, ERS-2, GFO

The ubiquitous ocean eddy field at scales of 25-250km lead to strong circulations that need to be resolved.



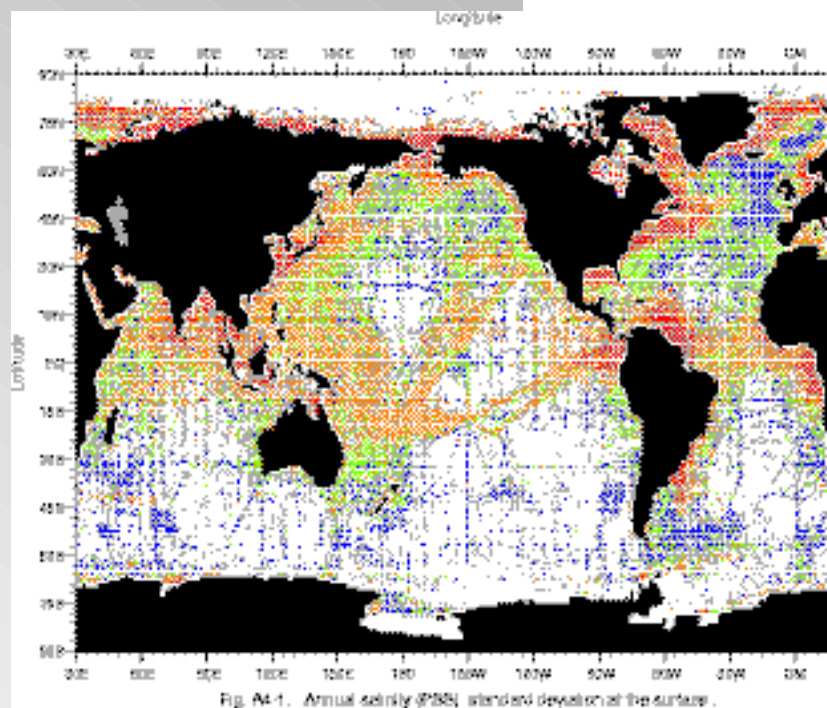
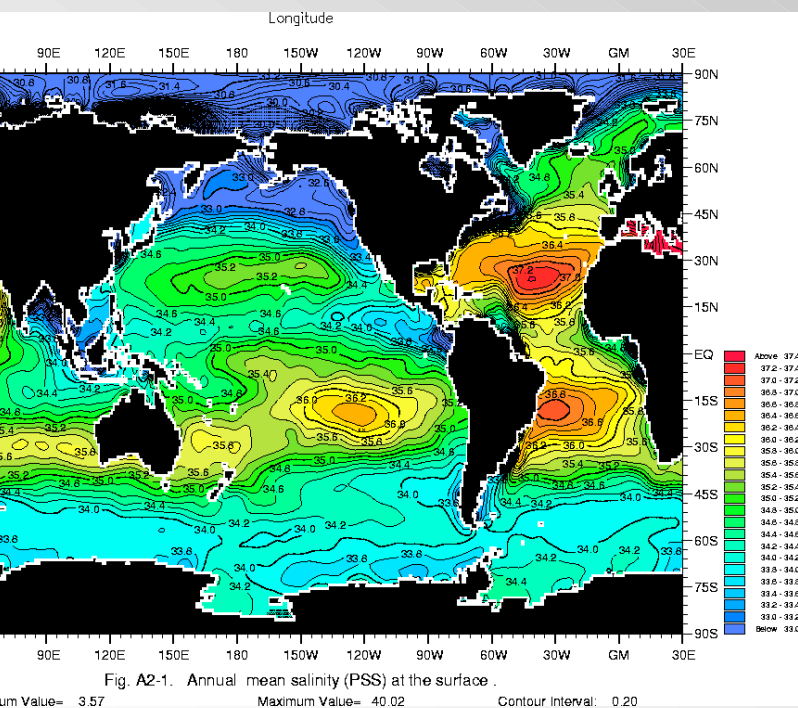
Surface Topography



- 00-05 Plan: 2 satellite altimeters (Jason-1, Envisat) and new gravity measurements (GRACE, GOCE)
- 05-15 Challenges:
 - Improve Resolution ($<25\text{km}$, 10 days)
 - Resolve cross-track gradients to fully determine surface circulation
- Technology: Microwave altimeter, interferometer, radiometer, GPS - Interferometric boom short-term stability, boom metrology, light/efficient amplifiers & receivers, onboard integrated processing, radiometer/radar antenna share.
- Precision Navigation, Formation Flying, Onboard Processing, Interferometry, Large antenna

Sea Surface Salinity

Understanding the impact of the global water cycle on the ocean and climate



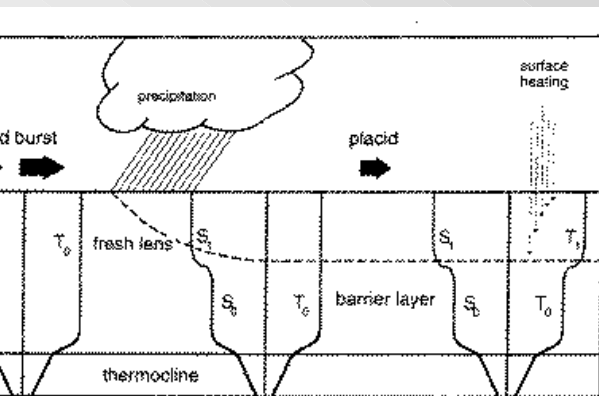
What is needed every week from space

What is available after 100 years of satellite

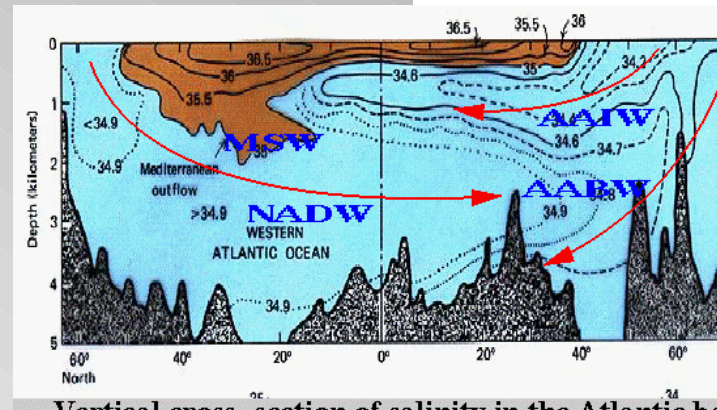
Sea Surface Salinity

Understanding the impact of the global water cycle on the ocean and climate

Science Impacts

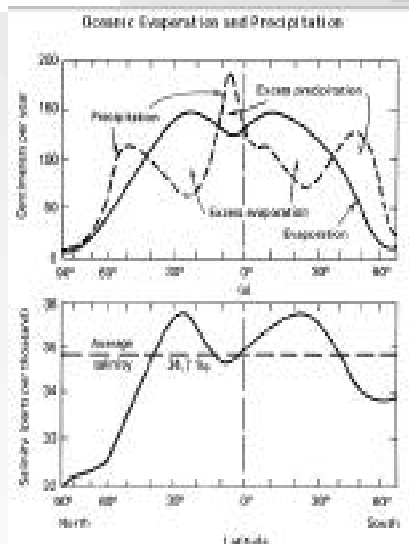


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Vertical cross-section of salinity in the Atlantic basin

**The tropical barrier layer
ENSO and the Monsoons**



**The thermohaline circulation
The impact of high latitudes**

The hydrologic cycle and the ocean

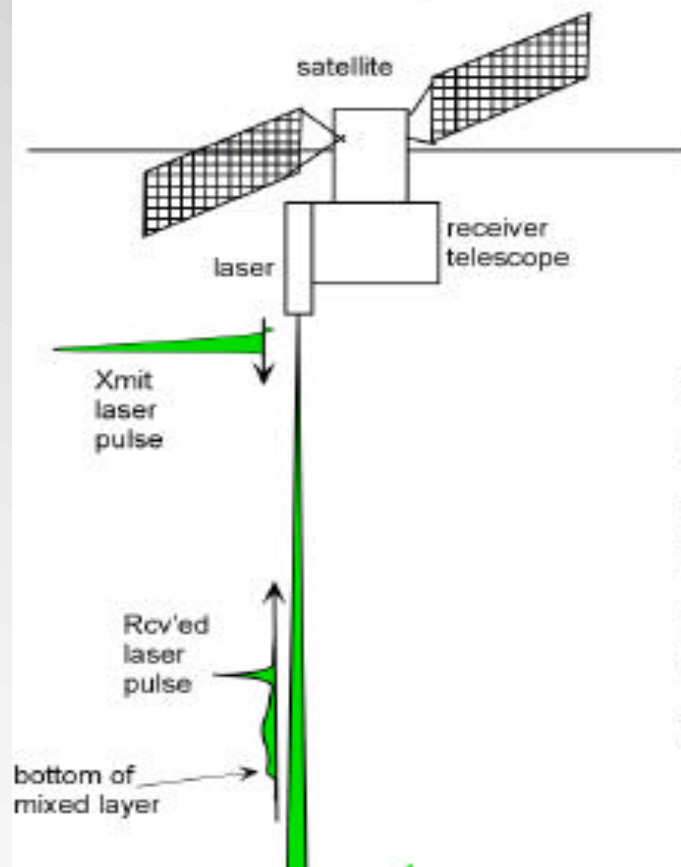
Sea Surface Salinity



- 00-05 Plan: Develop prototype ($<0.1\text{K}$, 100km , weekly),
- 05-15 Challenges:
 - Prototype in space,
 - 0.05°K Radiometric accuracy at L band,
 - improve radiometric calibration,
 - Multiple frequency approach to hydrologic cycle,
 - Improve resolution (10km) and coverage (daily).
- Technology: Large, lightweight, deployable, efficient, steerable antenna ($5\text{-}10\text{m}$); high accuracy multi-frequency radiometers (0.05K); microwave calibration.
- Large Antenna, Formation Flying (e.g., GPM)

Ocean Mixed Layer Lidar - Measurement Concept

J. B. Abshire and X. Sun
NASA GSFC, Code 924
5-26-99



Lidar characteristics:

Wavelength: 532nm

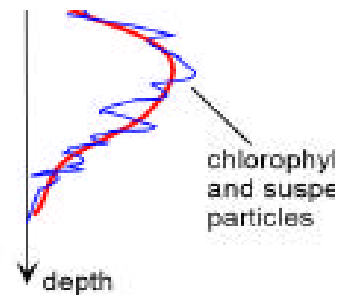
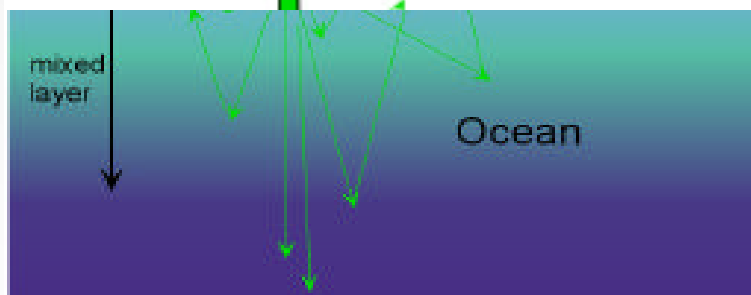
Power aper product $> 10^5 \text{ sWm}^2$

Laser pulse rep rate $> 100 \text{ Hz}$

Photon counting receiver

Meter level depth resolution

High dynamic range (10^4) rec



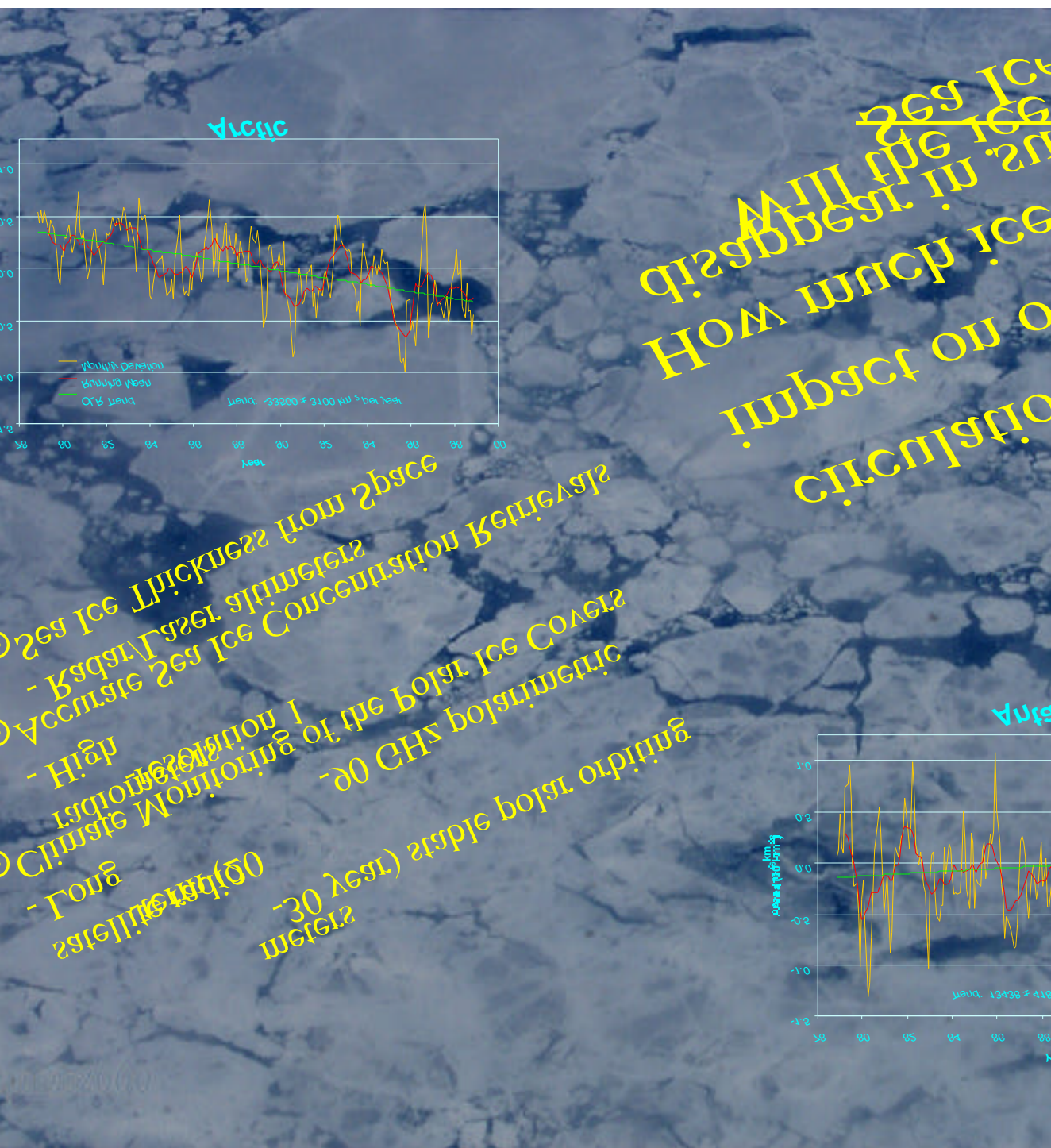
New Challenges

Detect the depth of the upper ocean boundary layer measuring the depth of the scattering layer with lidar

The mixed layer provides critical information about air-sea interactions. Heat, freshwater, and momentum exchanges, and as information about upper productivity.

Mixed Layer Depth

- 00-05 Plan: Development - Connection between scattering layers and mixed layer depth, surface reflection, determine “eye safe” aperture and receiver size for space system
- 05-15 Challenges: Space experiment – Space Station ?
- Technology: Large deployable, lightweight antenna; dynamic range of detectors; increase number of laser shots
- Laser Technology, Precision Navigation, Formation Flying



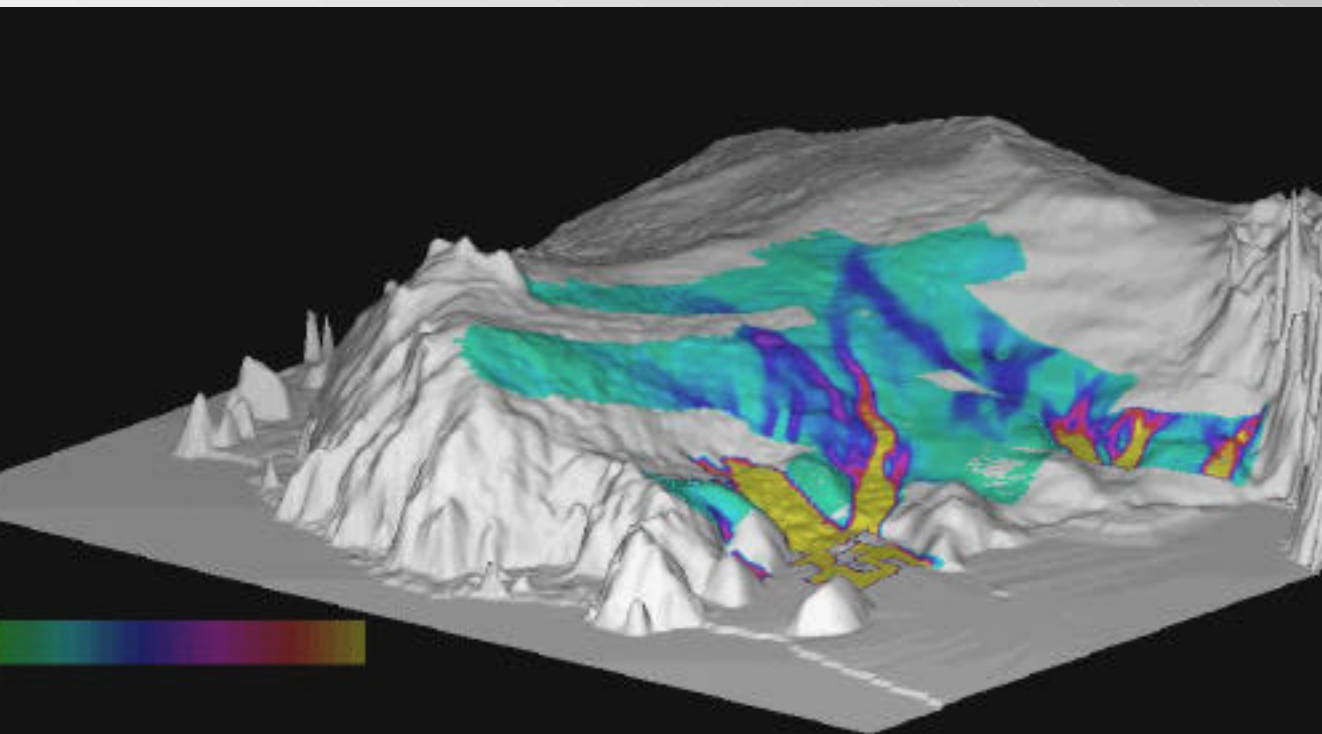
Sea Ice

Concentration, Extent, Motion, Thickness

- 00-05 Plan: Passive/active microwave (SSM/I, AMSR, SeaWinds, etc.). Thickness test w/ ESA Cryosat, ICESAT.
- 05-15 Challenges:
 - Improve resolution and coverage;
 - Extend to lower frequencies to sort out ice types (e.g. meltponds vs open water).
- Technology: Large, lightweight, deployable steerable antenna; compact, low-power electronics (MMIC, etc.)

Ice Sheets

Are the ice sheets growing or shrinking (direct effect on sea level)?
What changes in the flow of the ice sheet will affect ice sheet size?
What impact does ice-sheet discharge have on oceanic circulation and chemistry?
How do the bright, high-elevation ice sheets impact atmospheric circulation and
the radiative balance?



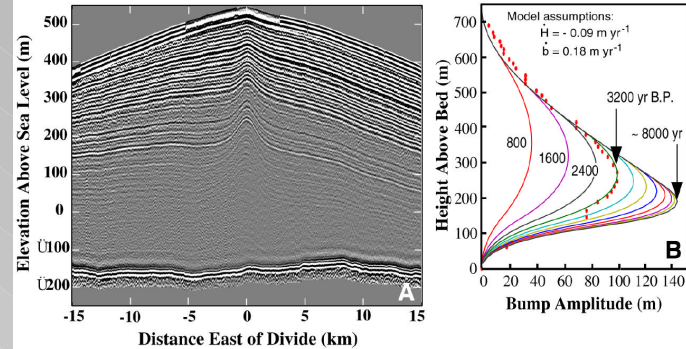
Ice Stream Velocities from SAR on West Antarctic Ice Sheet

Ice Sheets

Topography

- 00-05 Plan: ICESAT laser topography mission
- 05-15 Challenges: Follow on mission
- Technology: Extended shot lasers ($>10^9$), compact lidar system, stable laser sources, lightweight solar panels, pointing (metrology).
- Laser Technology, Precision Navigation (metrology)

Ice Sheets Characteristics



Layering at Siple Dome

- 00-05 Plan: Measure Ice Flow with SAR as available, Coarsely spaced ice thickness and subglacial characteristics from aircraft, rough estimates of accumulation.
- 05-15 Challenges:
 - More high latitude coverage (SAR) for monitoring ice stream flow,
 - Imaging ice penetrating SAR (50-200 Mhz) for internal layer structure.
- Technology: low frequency radar, large antenna, navigation (metrology), onboard processing.

Summary

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